ATTACHMENT C

UPDATED MACROECONOMIC ANALYSIS OF CLIMATE STRATEGIES PRESENTED IN THE MARCH 2006 CLIMATE ACTION TEAM REPORT USING THE E-DRAM MODEL

FINAL REPORT

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LIST OF EXHIBITS

C.1 Introduction

This report provides an update to the macroeconomic analysis of the climate strategies presented in the March 2006 Climate Action Team Report to Governor Schwarzenegger and the Legislature (2006 CAT Report). This appendix discusses the analysis performed using the Environmental Dynamic Revenue Analysis Model (E-DRAM) provided by the Air Resources Board (ARB).

The remainder of this section is organized as follows:

- Section C.2 presents an overview of the E-DRAM model;
- Section C.3 summarizes the scenarios that were analyzed;
- Section C.4 summarizes the model results; and
- Section C.5 provides some further discussion.

C.2 Economic Models

This economic assessment uses a computable general equilibrium (CGE) model of the California economy called E-DRAM, developed by the University of California, Berkeley. E-DRAM has been used by the Department of Finance for the revenue impacts of tax and other State policies, by the California Energy Commission and ARB to assess impacts of reducing petroleum dependency (AB2076)[1].and by ARB for the Vehicle Climate Change Standards[2], the State Implementation Plan[3] analysis, and others. As a part of the application of the model to these analyses, it has been peer reviewed and calibrated to be representative of the California economy.

A CGE model simulates the functioning of a market economy in which different sectors interact with one another (one sector supplies inputs to another, or purchases the outputs of another) and where prices and production adjust in response to changes caused by government policies applied to specific sectors. The CGE simulates these relationships among California producers, California consumers, government, and the rest of the world. Because of the interconnection between sectors, an intervention in one sector has impacts on others, which are captured by the CGE model analysis.

Exhibit C.1 illustrates a simplified version of the sectors that interact and participate in goods, services, and labor flows that make up the economy. The diagram shows that the households sell factors of production (labor and capital) to the firms which use the factors to produce goods and services to sell to the households. It also shows the flow of payments that accompany the transactions between the firms and the households. The diagram includes the flow of transactions between the firms; as the firms buy and sell intermediate goods amongst themselves to produce the final products sold to the households.

Exhibit C.2 illustrates the complexity of the complete California economy and the many sectors involved in producing goods and services for final consumption by the households inside and outside of California.

[1] CEC 2004. Attachment to Appendix A (Revised): Impacts of Petroleum Reduction Strategies on the California Economy. Available at http://energy.ca.gov/fuels/petroleum_dependence/documents/2004-02-10_ATCHMNT_APNDX_A.PDF
[2] ARB 2005a. Regulations To Control Greenhouse Gas Emissions From Motor Vehicles: Final Statement Of Reasons. Available at http://www.arb.ca.gov/regact/grnhsgas/fsor.pdf
[3] ARB 2003, 2003 State and Federal Strategy for the California State Implementation Plan. Available at http://www.arb.ca.gov/planning/sip/stfed03/stfed03.htm

Exhibit C.1: Circular Flow of Goods and Services in the Economy

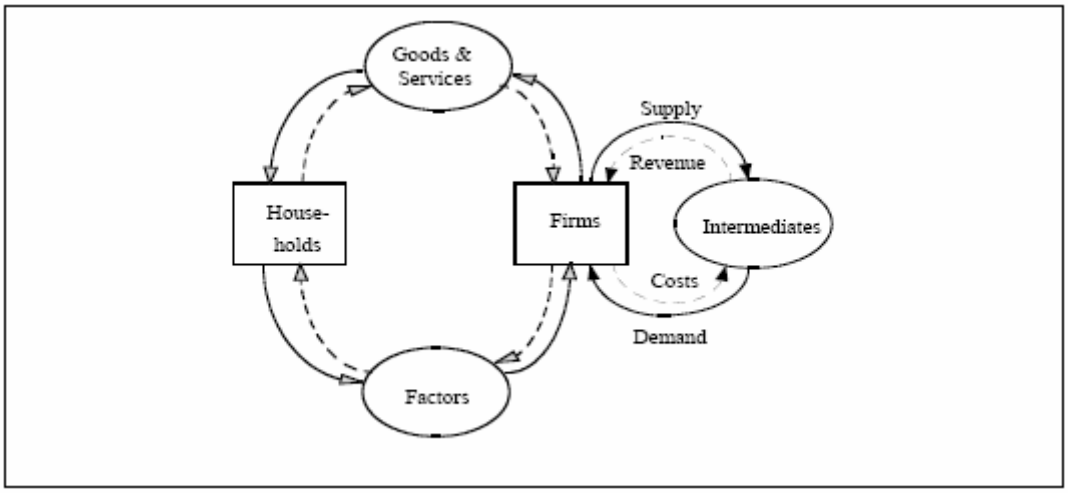
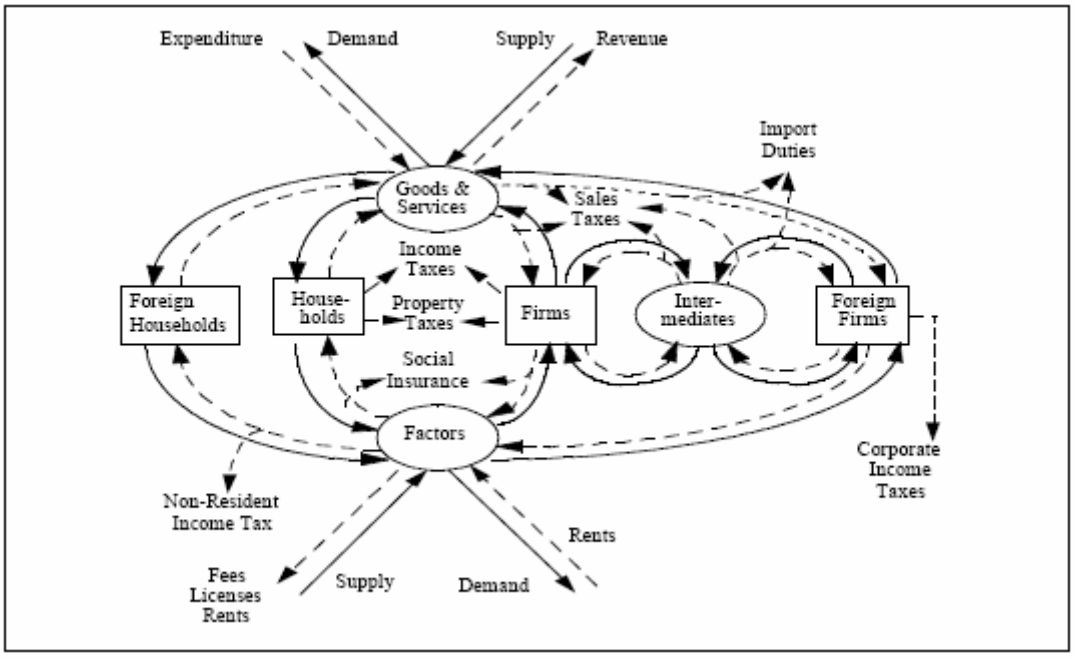


Exhibit C.2: Circular Flow of Goods and Services in the Economy



At the core of all of these models is a Social Accounting Matrix (SAM) which represents the flows of all economic transactions that take place within an economy. The SAM is an array of input-output accounts that are denominated in the units of value of the period for which the flows are recorded, typically the currency of the benchmark year. The current version of E-DRAM has 119 industrial sectors in its Social Accounting Matrix (SAM). The SAM was assembled by Professor David Roland-Holst of the Department of Agricultural & Resource Economics at UC Berkeley for use in the E-DRAM and BEAR models.

When a regulation or a policy is adopted that could affect costs of production in one part or sector of the economy, the rest of the economy adjusts to the perturbation through price or employment changes. The CGE tracks the changes and produces results that show how much each sector has changed. The main economic indicators are number of jobs and income. It is

believed that these two key indicators are particularly informative for characterizing the impact of potential policies on California's economy. Jobs are an important indicator for decision-making, and income closely follows the gross state product, which is an indicator of overall economic well-being in the State. This economic assessment presents the changes in these two indicators as the net economic impacts of the strategies.

C.3 Scenarios Analyzed

E-DRAM analyzed nine scenarios that reflect a range of policies and programs for achieving the state's 2020 emissions target. The scenarios were defined in terms of the following:

- ***Emissions Target:*** All nine scenarios incorporate the same emissions target of reducing GHG emissions in 2020 to 1990 levels. Using the baseline emissions forecast from the 2006 CAT Report, an emission reduction of 174 $MMTCO_2e$ is required in 2020.
- ***Climate Strategies:*** E-DRAM incorporated the climate strategies presented in Section 2.3 of the main report to characterize the emission reductions achieved through the State's actions. To assess the impact of failing to obtain emission reductions from the climate strategies, a sensitivity case was defined in which the emission reductions, costs, and savings of the strategies are reduced by 50% across the board. The estimates for this sensitivity case provide an indication of how the economy may be affected if these (or other) strategies are not implemented in a manner that can deliver the emission reductions as anticipated.
- ***Cap and Trade Program:*** Recognizing that no decisions have been made regarding whether a cap-and-trade program will be used in California, the updated analysis incorporates a cap and trade program as a market-based compliance mechanism for achieving the emission cap. The Market Advisory Committee's Report (MAC Report) discusses the design elements of a cap-and-trade system.[4] Typically, a cap is specified as a mandatory limit on the total emissions that can be released in a given period from sources included under the cap. Sources covered by the program can buy and sell allowances from each other. The ARB has yet to analyze fully the MAC Report recommendations.

  For purposes of this analysis, two representations are used to illustrate the range of potential program designs. **Program A** sets the cap across the entire California economy, putting all emissions sources under the cap. This program is similar in its impact to the MAC Report Program 4 -- upstream coverage of carbon in fossil fuels and downstream coverage of large sources of non-CO_2 gases and some suppliers of high GWP gases. **Program B** sets the cap on a narrower subset of sources in the California economy, focusing on the energy intensive industries, including the electric sector (including imported power), the cement sector, and the refining sector. Program B is similar to the MAC Program 1 – coverage of medium and large point sources of emissions, and some suppliers of high GWP gases. These two specifications, Program A and Program B cover the full breadth of the options discussed in the MAC Report.

  In all scenarios examined, the cap starts in 2012 and declines linearly to the 2020 emission target. Under Program A, all sources in the state can contribute to the emission reductions. Under Program B, only sources in the energy intensive sectors can contribute to emission reductions, so that the energy intensive sectors bear a disproportionate emission reduction burden. No cost minimizing methods, such as emission allowance banking or borrowing,

[4] See Market Advisory Committee. 2007. "Recommendations of the Market Advisory Committee to the California Air Resources Board." Available at http://www.climatechange.ca.gov/documents/2007-06-29_MAC_FINAL_REPORT.PDF

are included in the analysis. However, several specifications for offsets are examined, as described next.

- ***Offsets:*** An offset is a credit for an emission reduction that is achieved by an entity outside of the sectors covered by the cap-and-trade program. If offsets are included in a cap-and-trade program, entities under the program can meet their emission reduction obligations by purchasing offsets. The extent to which offsets may be used is one of the design decisions required for a cap-and-trade program. Both the European Union Emissions Trading Scheme (EU ETS) and the Regional Greenhouse Gas Initiative (RGGI) allow offsets to be used to some extent.

  As mentioned above, no decisions have been made regarding whether a cap-and-trade program will be used in California. Similarly, recognizing that no decision has been made regarding whether offsets may be part of such a program were it adopted, the updated analysis examines a range of assumptions regarding the use of offsets to achieve emission reductions under the cap. The analysis includes a scenario with no offsets at all. Separate scenarios are also specified in which offsets are can account for up to 10% of the emission reduction required to be achieved. In 2020, the offsets may be used to account for 10% of the 174 $MMTCO_2e$ of emission reductions required, or 17.4 $MMTCO_2e$. The cost of the offsets cannot be known at this time because the cost will depend on the types and locations of emission reductions that may be eligible for offsets. This analysis explores a range of offset prices, including $10/ton, $30/ton and $50/ton. The low-cost offset scenario may be reflective of a program that allows the purchase of offsets from anywhere outside of California. The higher-cost offset scenarios may be reflective of a program that limits offsets to specific types of emission reductions or to reductions only within certain geographic areas.

- ***Energy Prices:*** The analysis adopts the energy prices described in Section 2.2.2 of the main report. A scenario is analyzed to assess the sensitivity of the results to the alternative natural gas price forecast presented in that section.

Exhibit C.3 lists the combinations of the variables that comprise the nine scenarios analyzed. As shown in the exhibit, the scenarios can be grouped as follows:

- ***Reference Case:*** Scenario 1 is the reference scenario against which the other scenarios can be compared.
- ***Offsets:*** Scenarios 2-4 examine the potential impact of including offsets.
- ***Scope:*** Scenarios 5-6 examine the implications of adopting a cap and trade program with a narrow scope focused on selected sectors, i.e., Program B.
- ***Climate Strategies:*** Scenarios 7-8 present the sensitivity cases regarding the climate strategy emission reductions.
- ***Energy Prices:*** Scenario 3* examines the energy price sensitivity case, using the CPUC natural gas price forecast with the other assumptions in Scenario 3.

Although these nine scenarios reflect a range of possible programs and policies, many additional scenarios are of interest and warrant analysis. For example, analyses of alternative cost containment mechanisms are of interest, as are assessments of alternative methods for allocating emission allowances under a cap and trade program. These and many other program design questions remain to be examined.

Exhibit C.3: Scenarios Analyzed

Analysis Cases	Climate Strategies[1]	Cap-and-Trade Program[2]	Offsets[3]	Energy Prices[4]
Baseline	None	None	None	IEPR Forecast
Scenario 1	Reference Case	Program A: All Sectors	None	IEPR Forecast
Scenarios 2-4: The Impact of Allowing Offsets				
Scenario 2	Reference Case	Program A: All Sectors	$10/ton	IEPR Forecast
Scenario 3	Reference Case	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 4	Reference Case	Program A: All Sectors	$50/ton	IEPR Forecast
Scenarios 5-6: The Impact of Narrowing the Scope of the Cap and Trade Program				
Scenario 5	Reference Case	Program B: Major Sectors Only	None	IEPR Forecast
Scenario 6	Reference Case	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenarios 7-8: Sensitivity Case Examining What if the Climate Strategies Produce only 50% of Their Expected Reductions				
Scenario 7	Sensitivity Case: 50% Effective	Program A: All Sectors	$30/ton	IEPR Forecast
Scenario 8	Sensitivity Case: 50% Effective	Program B: Major Sectors Only	$30/ton	IEPR Forecast
Scenario 3*: Energy Price Sensitivity Case				
Baseline	None	None	None	CPUC MPR Forecast
Scenario 3*	Reference Case	Program A: All Sectors	$30/ton	CPUC MPR Forecast

1. Reference Case climate strategies listed in Exhibit 11 of the main report. The sensitivity case uses 50% of the emission reductions, costs, and savings.

2. Program A sets the cap across the entire California economy. Program B sets the cap across the energy intensive sectors, including the electric sector (including electricity imports), the cement sector, and the refining sector.

3. Offsets can account for up to 10% of the required emission reduction. In 2020, offsets can account for up to 10% of the 174 $MMTCO_2e$ emission reduction required, or 17.4 $MMTCO_2e$.

4. The energy prices are based on the 2005 Integrated Energy Policy Report (IEPR) forecast. The Sensitivity Case is based on the CPUC Market Price Referent (MPR) natural gas price forecast (see Section 2.2.2 of the main report).

C.4 Model Results

The reported measures of economic impact include: real state output, personal income, and employment. Also reported are the volume of emission reductions and the associated emission allowance price from the cap-and-trade program. Economic and emission impacts are reported as the percent change from the Baseline forecast of economic and emissions growth. As described below, it was not possible to analyze estimate all of the scenarios in E-DRAM.

Exhibit C.4 details the impacts of the scenarios in 2020. In all scenarios, the impacts on output and personal income are small but positive, ranging from 0.4% to 0.7% for output and 0.5% to 0.9% for personal income. Employment impacts range from a loss of 0.3% to a gain of 0.4%. As was discussed in Section 2 of the main report, many of the strategies have savings that exceed their costs. The positive impacts result largely because of the net savings associated with many of the strategies.

Observations regarding the results include the following:

- ***Offsets:*** The impact of allowing offsets is reflected by comparing Scenarios 2 through 4 with Scenario 1. Whereas Scenario 1 includes no offsets, Scenarios 2 through 4 include offsets at increasing prices. With offsets available at $10/ton, E-DRAM indicates that impacts on state output are reduced compared to Scenario 1. As offsets become more expensive, they have less influence on the results. For example, at prices of $30/ton and $50/ton, E-DRAM estimates that no offsets would be purchased because the estimated allowance prices are less than the offset prices.
- ***Scope:*** Scenarios 5, 6, and 8 represent narrowing the scope of the cap-and-trade program to the energy intensive sectors. Currently E-DRAM is unable to model these scenarios.
- ***Climate Strategies:*** Scenarios7 examines the implications of obtaining only half of the anticipated emission reductions from the climate strategies. In this scenario, E-DRAM indicates less of a positive impact on income compared to Scenario 1, and employment impacts are now negative. Estimated allowance prices in Scenario 7 are substantially higher than the prices in the other scenarios.
- ***Energy Prices:*** Scenario 3* is a sensitivity case that uses an alternative forecast for natural gas prices, and is best compared to Scenario 3. E-DRAM indicates a decreased positive impact, though the differences are not substantial.

Overall, the modeling results indicate that the state's emission target for 2020 can be achieved with small positive economic impacts through 2020. The results also indicate that there is value in implementing policies that promote emission reductions as broadly as possible throughout the economy.

C.5 Further Modeling Efforts

This analysis is preliminary in many respects, and significant work remains to be performed to support ARB's Scoping Plan. As discussed in the main report, the climate strategies continue to be refined and updated, and new climate strategies are under development (such as the Low Carbon Fuel Standard). The analysis must be revised to incorporate these updated and new strategies and improved modeling capabilities must be developed. The CPUC and ARB are currently developing improved modeling tools to address this need, which will improve the basis for future analysis.

Additionally, a number of important cap-and-trade program design elements (e.g., allocation of allowances, banking, safety-valves, etc.) along with other market-based policies warrant

complete and thorough investigation and analysis. The modeling tools need to be enhanced to examine many of these issues.

Exhibit C.4: E-DRAM Modeling Results

Impact Indicator	Real State Output	Personal Income	Employment (Millions)	Emissions (MMTCO2e)	Allowance Price
Baseline Case	$3,497	$2,031	18.4	610	
Scenario 1	$3,504	$2,049	18.5	436	$21
Offset Scenarios					
Scenario 2	$3,512	$2,049	18.5	453	$13
Scenario 3	$3,504	$2,049	18.5	436	$21
Scenario 4	$3,504	$2,049	18.5	436	$21
Scope Scenarios					
Scenario 5	NA	NA	NA	NA	NA
Scenario 6	NA	NA	NA	NA	NA
Climate Strategy Scenarios					
Scenario 7	$3,463	$2,041	18.3	452	$45
Scenario 8	NA	NA	NA	NA	NA
Energy Price Sensitivity Scenario					
Baseline Case	$3,497	$2,031	18.4	610	
Scenario 3*	$3,507	$2,048	18.5	437	$17
Changes from Baseline Case					
Scenario 1	0.2%	0.9%	0.3%	-28%	$21
Offset Scenarios					
Scenario 2	0.4%	0.9%	0.4%	-26%	$13
Scenario 3	0.2%	0.9%	0.3%	-28%	$21
Scenario 4	0.2%	0.9%	0.3%	-28%	$21
Scope Scenarios					
Scenario 5	NA	NA	NA	NA	NA
Scenario 6	NA	NA	NA	NA	NA
Climate Strategy Scenarios					
Scenario 7	-1.0%	0.5%	-0.3%	-26%	$45
Scenario 8	NA	NA	NA	NA	NA
Energy Price Sensitivity Scenario					
Scenario 3*	0.3%	0.8%	0.3%	-28%	$17

NA: E-DRAM was not able to analyze these scenarios

* Output and personal income are expressed in Billions of 2006 dollars.